THE

TACONIC AND LOWER SILURIAN ROCKS

OF

VERMONT AND CANADA.

BY JULES MARCOU.

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At the meeting of Oct. 17, 1860, I had the honor to read before the Society extracts from three letters of M. Barrande, relating to the stratigraphical position of the primordial fauna in North America. Two of those letters were addressed to me, the third was a copy of a letter to Professor Bronn of Heidelberg. I added a few remarks, and the whole was published in the *Proceedings*, Vol. vii. p. 369, under the title, "*On the Primordial Fauna and the Taconic System*, by Joachim Barrande, *with additional notes* by Jules Marcou."

The views there exposed were received with little favor, at first, by those geologists who, for the last fifteen years, have refused to recognize the Taconic system, on the ground that it was not sustained by any stratigraphical, paleontological, or lithological evidence. It was hard for them to admit that the paleontological character at least was against them, some going so far even as to deny the validity of paleontological evidence in determining the age of strata. As the same persons have long considered the lithological character "entirely valueless," American geology was deprived of its two best supports, and left entirely at the mercy of suppositions and conjectures. It was evident, however, that the summary method, so frequently used, of suppressing observations which did not agree with the views of those regarded by some as the best and highest authorities on this continent, could not succeed now, as it was impossible to rule out the science of paleontology and its supporters.

Three months later, Mr. Logan of Montreal, in a letter to M. Barrande (in which he inadvertently omitted to mention our Boston pamphlet), admits that the views entertained by him on the rocks of Point Levi and Georgia were erroneous, and tries to explain the position of strata at Point Levi, putting together all the rocks found there, as the "*Quebec group of rocks.*"

Mr. James Hall, of Albany, in a letter to the editor of *Silliman's Journal*, one month later, takes up the paleontological evidence, letting it be understood that, if any mistake was made, it was due to stratigraphy; and mixing together, even more than Mr. Logan had done, all the fossils found in the various places and strata at Point Levi, he comes to the conclusion that "M. Barrande's plan of successive Trilobitic faunæ" *does not meet the case* in hand; and, without giving any decisive opinion, he evidently leans toward the view that he has always entertained, in common with the Professors Rogers, of the Hudson River group.

This letter of Mr. James Hall appeared in *Silliman's Journal* of March, 1861, together with a reprint of Mr. Logan's letter, and also a

part of our pamphlet, under the altered and false title * of, *On the Primordial Fauna and the Taconic system of Emmons, in a letter to Prof. Bronn of Heidelberg.*

While these publications were in progress in America, M. Barrande, in the *Bulletin de la Société Géologique de France*, Vol. xviii. p. 203, at the meetings of Nov., 1860, and Feb., 1861, gave a long, elaborate, and impartial memoir, entitled, "*Documents anciens et nouveaux sur la faune primordiale et le système Taconique en Amérique*, with two plates; in which he gives at length the numerous, sagacious, and profound observations of Dr. Emmons on the Taconic system, so long kept in the background.

Professor Agassiz, who has contributed much to the enlargement of our views and notions as to the great value of paleontological characters for the determination of the relative age of strata, desirous to assist in the elucidation of the difficulty, signalized with such a masterly hand by M. Barrande, sent me to Vermont and Canada to collect all the specimens of fossils, and all the facts I could reach, for the benefit of his Museum of Comparative Zoology. I give below a very summary resumé of what I have seen, reserving all the detailed sections, new fossils, and geological maps, for a longer memoir now in preparation.

I must begin by the statement that the Taconic system of Dr. Emmons is the true base of the sedimentary strata in North America, and that I agree in the main with all the observations, sections, and descriptions of fossils of Dr. Emmons, who, in establishing the foundation-stone of the pillar of American Stratigraphy, has given in his different memoirs on the Taconic system the most difficult and important geological works which have ever been produced on this side of the Atlantic.

My researches were principally directed toward the upper part of the Taconic series and the Lower Silurian, and I give a tabular view, showing the succession of groups of strata. This I was able to make out for the vicinity of Georgia, St. Albans, Swanton, Highgate-Springs, and Phillipsburgh, on the north-eastern shore of Lake Champlain.

Lorraine Shales. — This group, which has been also called *Pulaski Shales* and *Hudson River Group*, does not occur at Snake Mountain, nor in the vicinity of St. Albans, Georgia, Swanton, and Highgate. Indeed, I did not find a single trace of this group anywhere on the main land of Vermont, and I only saw it on the peninsula of Alburgh, between Missisquoi Bay and Rouse's Point, where it presents the rocks

* I regret to say that this is the second instance since 1858 in which the editors of *Silliman's Journal* have not only appropriated letters belonging to me, but attributed them to persons who have had nothing whatever to do with them.

THEORETICAL SECTION OF THE UPPER TACONIC AND LOWER SILURIAN ROCKS OF VERMONT.

	GROUPS.	FEET.	LOCALITIES, SUBDIVISIONS, AND FOSSILS.	
LOWER SILURIAN.	LORRAINE SHALES.		Alburgh Peninsula.	Second fauna.
	UTICA SLATE.	40	Highgate-Springs.	
	TRENTON LIMESTONE.	60	Highgate-Springs.	
	BLACK RIVER GROUP.	40	At the base a blue limestone, very fossiliferous, with *Ampyx Halli*; 2 feet. Highgate-Springs.	
	CALCIFEROUS SANDSTONE.	700 to 900	3. Gray and blue shales, containing nodules of blue limestone, with fossils; about 150 feet. East of Phillipsburgh (Billings). 2. Blue and black limestone, very fossiliferous (*Bathyurus Saffordi*); about 300 feet. Phillipsburgh (Billings). St. Albans Bay. 1. Gray and almost white limestone, containing numerous veins of calc-spar, marble, and magnesian limestone; about 300 feet. Phillipsburgh (Billings). St. Albans Bay. Swanton.	Second fauna.
	Overlie the Taconic strata in discordance of stratification.			
UPPER TACONIC.	POTSDAM SANDSTONE.	300 to 400	4. Dolomitic conglomerate; 30 feet. Saint Albans. 3. Red sandstone, with *Conocephalites Adamsi, C. Vulcanus*; 80 feet. Saxe's Mills. St. Albans. 2. Dolomite; 150 to 200 feet. Saxe's Mills. Swanton. St. Albans. 1. White and red sandstone; 40 feet. St. Albans Bay.	Primordial fauna.
	LINGULA FLAGS.	500 to 600	Brown, green, and blackish slates, with *Lingulæ, Orthisina. Orthis, Chrondites, Graptolites*. Highgate-Springs.	
	GEORGIA SLATES.	500 to 600	Gray, black, sandy slates, with *Paradoxides (Olenellus) Thompsoni, P. Vermontana, Peltura holopyga, Con. Teucer, Obolella cingulata, Orthisina festinata, Camerella antiquata, Chrondites, Fungus*. W. Georgia. Swanton.	
	ST. ALBANS GROUP.	2500 to 3000	Green, brown, and reddish slates, containing large lenticular masses of very hard, whitish-gray limestone. Trilobites. St. Albans. Georgia Centre.	

Quartzite, Conglomerates, and Talcose slates. Between St. Albans and Fairfield, and belonging to the Lower Taconic.

and fossils which characterize it at Sandy Creek, the typical locality of Jefferson county, in the State of New York.

Utica Slate. — The only locality where I met with these strata was on the shore of Lake Champlain, a short distance behind the hotel of Highgate-Springs. The thickness of what is not covered by the water is forty feet; they have been overturned, and lie below the Trenton Limestone. Dr. G. M. Hall, of Swanton, has found this group on several of the islands in the middle of the lake.

Trenton Limestone. — This group, with its usual characters, is found at Highgate-Springs.

Black River Group. — Comprising the *Black River limestone*, *Birds-eye limestone*, and *Chazy limestone*. It is common to find now and then, scattered along the whole line from Highgate-Springs to Bridgeport, in small patches, lying in discordant stratification over the different divisions of the upper Taconic, some beds of limestone of this group. The thickness seldom reaches forty feet. They contain numerous fossils characteristic of the group. Localities: Highgate-Springs, West Georgia (near Mr. Parker's house), and Snake Mountain. At Highgate-Springs the last bed of the Black River group is formed of a hard, blue, grayish limestone, two feet thick, with *Ampyx Halli*, very fossiliferous, and constituting a very conspicuous and easy *point de repère*.

Calciferous Sandrock. — Until lately this group was not considered of the importance that it really is, and it is due mainly to the researches of Mr. Billings, of Montreal, that we have at last come to a true knowledge and understanding of its characters, and the great place it occupies in the Lower Silurian. In fact, the Calciferous Sandrock is the base of the Lower Silurian, and contains half the thickness of the beds composing the Lower Silurian of North America. In the *Paleontology of New York*, by James Hall, Vol. i., thirteen or fourteen fossils are described as being the only remains of organized beings found in the Calciferous Sandstone, whereas now Messrs. Jewett, Billings, G. M. Hall, Perry, Farnsworth, J. Richardson, J. Bell, and myself, have succeeded in collecting from this group in Vermont, New York, Canada, and at Belle Isle (Newfoundland), more fossils than in all the other Lower Silurian groups put together, — that is to say, about twelve hundred species, of which one hundred are new Trilobites. To any one, however, acquainted with the different Silurian faunæ of Europe, it was evident that the second fauna of North America had not been well worked out by the Paleontologist of New York, and that at least a good half of it had escaped his hasty and superficial researches in the field; so that this discovery of numerous fossils belonging to the second fauna in the Calciferous Sandstone, however sudden it might be, was not unexpected to any one who has studied the different memoirs of Barrande on the subject.

A series of gray and blue shales, containing nodules of blue limestone, with fossils characteristic of the Calciferous Sandrock, was discovered in August last by Mr. Billings, ten miles east of Phillipsburgh, on the road to Freligsburgh, in Canada. Mr. Billings saw it lying over the limestone that forms the following subdivision, but was unable to make out its thickness, and its junction with the Black River group, so that giving about one hundred and fifty feet for it is a mere guess.

The second subdivision in descending the series has been called by Mr. Billings, in his interesting memoir, entitled, *On some Rocks and Fossils occurring near Phillipsburgh, Canada East* — (see the *Canadian Geologist*, August, 1861, p. 310, Montreal,) — *Blue, Thin-bedded and Nodular Limestone.* As Mr. Billings has given a good description of it, I will not repeat it here. The fossils are very numerous one mile east of Phillipsburgh, and just behind the houses of the village of St. Albans Bay. The most characteristic are, *Camerella calcifera; Orthis; Maclurea matutina; Ophileta sordida, O. levata, O. complanata; Ecculiomphalus Canadensis, E. intortus, E. spiralis; Pleurotomaria; Murchisonia; Holopea; Capulus; Orthoceras; Cyrtoceras; Nautilus; Lituites imperator, L. Farnsworthi; Bathyurus Saffordi, B. Cordai; Amphion Salteri; Asaphus;* Crinoids, Corals and Fucoids.

Below this subdivision, and passing gradually into it without any well defined line of separation, is a series of gray, almost white, limestone, containing numerous veins of calc-spar, white marble, and magnesian limestone. Mr. Billings has called it *Magnesian limestone*, but as true dolomite is found in large quantities in the middle of the Potsdam Sandstone group, I think this name will have to be changed. The fossils are rare in this lower subdivision, but Dr. G. M. Hall has found in it some Cephalopods and Gasteropods half a mile south-east of Phillipsburgh. This last subdivision was very plastic when first deposited, for it re-covers in discordant stratification the slates, and sometimes also the Potsdam Sandstone of the Taconic system, and follows all the accidents of the Taconic strata, as though they were covered with a sheet of paste or plastic clay. I regard it as the bottom rocks of the Silurian system in North America, containing the second fauna of Barrande. It can be observed at Phillipsburgh, on the shore line, east of Swanton, and north of St. Albans Bay. It may be that it forms the marble of Middlebury and Rutland, but I am unable to speak with any certainty, as it requires a special investigation, which I have been unable to make.

The Calciferous Sandstone always lies in discordance of stratification on the different groups of the Upper Taconic Strata; sometimes the discordance is 40°, generally 15° to 20°, and the direction of the *têtes de couches*, or strike, as it is called in English, cuts always the direction of the Taconic strata, at an average angle of 25°.

Potsdam Sandstone. — In Vermont the Potsdam Sandstone has exactly the same aspect and composition as at Potsdam, in the State of New York. Near Saxe's Mills, a mile east of the Highgate-Springs, it contains two species of *Conocephalites*, *C. Adamsi* and *C. Vulcanus*. Being the capping group of the Taconic in the *renversement* (overturn) of the strata, it has been broken into pieces and narrow parallel bands, which have rested upon the more inclined strata in a sort of unconformable stratification, very apparent everywhere, squeezing the Lingula-flags and Georgia Slates near the point of contact, and giving them for about two feet depth a sort of agitated structure (*structure tourmentée*). These narrow bands of Potsdam Sandstone are numerous and well developed west of Mr. Parker's farm at Georgia, and also on the road between St. Albans and Swanton; at first they appear to be interstratified with the Georgia Slates, but they are not so, and may be compared to the steps of a ladder placed over, or even a little wedged into the Georgia Slates and Lingula-flags. This group has been known for a long time in Vermont by the name of *Red Sandrock*. It is found all the way from Saxe's Mills to Western Georgia. It forms the top and eastern side of Snake Mountain, contrary to the view of Dr. Emmons, who refers these Snake Mountain rocks to the Calciferous Sandstone. All the fossils found until now in the Potsdam Sandstone of Vermont and New York are of primordial form; and there is also a great break and discordance of stratification between this group and the Lower Silurian; and I think the opinion I first expressed one year ago is fully justified by paleontological and stratigraphical evidences.

Below the Potsdam Sandstone lie great masses of slates, four or five thousand feet thick, which for convenience I should divide into three parts. No regular line of division can be traced between these three groups, as the strata pass from one to the other without any well marked difference; it is merely for the fossils, and as a matter of convenience, that I propose the division.

Lingula-flags. — The upper group, or Lingula-flags, is formed of brown, green, and blackish slates, five or six hundred feet thick, with numerous lines of cleavage, cutting the strata in all sorts of directions. In some parts the fossils are very numerous, and I found at Highgate-Springs, where I first saw them, in company with Dr. Hall, a quantity of *Lingulæ*, *Orthis*, *Orthisina*, and *Chrondites*. The *Lingula* is new, and the *Orthisina* is nearly related to, if not identical with, an *Orthisina* quite common in the Lingula-flags of Wales in Great Britain. Mr. Billings informs me that since my visit there he found at Phillipsburgh some *Graptolites*, in slates near the shore of the lake, which I consider as of the upper group, or Lingula-flags.

Georgia Slates. — The middle group, or Georgia Slates, is composed

of gray and black sandy slates, sometimes passing into a true yellowish sandstone, with nodules of oxide of iron, and spots of red oxide of iron on some slates. Thickness, five to six hundred feet. In this division, fifty yards from the house of Mr. Noah E. Parker, in West Georgia, the celebrated Georgia Trilobites were found. They were discovered accidentally, about six years ago, by Mr. Parker, in quarrying large slates for a floor. Having found one Trilobite, and not knowing what it could be, Mr. Parker showed it to the schoolmaster of the village, who wrote at once to the late Zadock Thompson, of Burlington, then State Geologist of Vermont. Mr. Thompson immediately visited the quarry, and made a collection of several specimens and species; unfortunately he died a short time after, without publishing anything about this discovery. The specimens having been placed in the hands of Mr. James Hall, that paleontologist described and figured them in a memoir under the very odd title of *Trilobites of the Shales of the Hudson River Group:* Albany, 1860. It was this title that startled Mr. Barrande so much, and was the occasion of bringing once more before the world, and this time not to be suppressed, the Taconic system of my learned friend Dr. Emmons. Mr. James Hall does not give a single geological fact to sustain his opinion of the Hudson River group; he regards it as a matter of course, beyond all doubt; and in order to give it a sanction which will make all discussion useless, he calls to his support the testimony of Mr. Logan (who, by the way, has never visited the locality), and adds, as overwhelming proof, that "it would be quite superfluous for him to add one word in support of the opinion of the most able stratigraphical geologist of the American continent." The only other geological indication that I have been able to find is in *Silliman's Journal* for January, 1861, p. 125, where Mr. James D. Dana calls the Georgia rocks "metamorphic black slates." I regret to say that all these statements and opinions are erroneous; there is no trace of the *Hudson River group* at Georgia, nor at any other place in the vicinity, and I was unable to find indications of metamorphism in any of the rocks there, for at least three miles around the quarry of Mr. Parker. The fossils are not numerous, with the exception of the *Chrondites;* and the Trilobites are certainly much less common there than the *Paradoxides Harlani* in the quarry of Mr. Haywood at Braintree. I found at West Georgia the three Trilobites described by Mr. James Hall, *Paradoxides* (*Olenellus*) *Thompsoni*, *P. Vermontana*, *Peltura holopyga;* and besides *Obolella cingulata*, a *Fungus*, *Chrondites*, and a *Bryozoon*, related to the *Graptopora socialis* (Salt.), all primordial fossils.

Until this summer West Georgia was the only place for these Trilobites. Two other localities have been added in the last two months. Dr. G. M. Hall and Rev. J. B. Perry have found the *P. Thompsoni*,

P. Vermontana, Obolella cingulata, Orthisina festinata, Camerella antiquata, Conocephalites Teucer, and *Chrondites*, a mile and a half east of the village of Swanton; and Mr. James Richardson has collected specimens of the same *Paradoxides* farther east, at L'anse au Loup, on the north shore of the straits of Belle Isle, Labrador; (see *New Species of Lower Silurian Fossils*, by E. Billings. Montreal, Nov., 1861).

Saint Albans Group. — The road between St. Albans and Georgia, and thence from Georgia to Mr. Parker's house, lies all the way on green, brown and reddish slates, containing now and then large lenticular masses of very hard, whitish-gray limestone. Thickness, between twenty-five hundred and three thousand feet. I did not find any fossils, although I heard of one specimen of Trilobite picked up behind the town of St. Albans by an inhabitant, nor was I able to see that specimen. The reddish slates, which are not well developed in Vermont, as regards the red color of the rocks, lie at the base of the upper Taconic strata. They are worthy of notice, as containing the veins of sulphuret and copper pyrites of the Acton mines, in Canada, and the Bruce and Wallace mines of Lake Huron.

Below the St. Albans group are quartzite, conglomerates, talcose slates, clay slates, mica-schist, and gneiss, with intercalation of beds and lenticular masses of crystalline limestone, resting on the unstratified and oldest crystalline rocks of the White Mountains, and composing the *Lower Taconic system.* Dr. Emmons did not put in his Lower Taconic the mica-schist and gneiss, which form the central and eastern part of Vermont, but on a close examination of the subject in the vicinity of Rutland, Bolton, and Island Pond, I have come to the conclusion that these rocks have a stratified and sedimentary origin, and that they are the base of the Taconic system. All the strata of the Lower Taconic system are more or less metamorphic, especially at the base; — the metamorphism produced by the action of mineral springs during the deposits, together with pressure caused by the divers dislocations to which they were afterward submitted. The Lower Taconic is at least ten thousand feet thick, making fifteen thousand feet the *minimum* for the Taconic system of Vermont. It is difficult to give the thickness of the strata with any exactness, as the Green Mountains present a fan-like structure, similar to that of the Alps and Pyrenees.

Twelve years after the discovery and description of the Taconic system, Mr. Logan, having met with some of the Taconic rocks on the southern edge of the Laurentine Mountains, between the Saguenay River and the Bruce mine on Lake Huron, and overlooking entirely the researches of Dr. Emmons, proposed to introduce into the table of the American strata two new systems, which he called the *Laurentian and Huronian systems;* (see *Esquisse Géologique du Canada*, Paris, 1855). The Laurentian system is composed of the Lower Taconic, to

which are added all the unstratified crystalline rocks forming the centre of the Laurentine Mountains, such as granite, syenite, diorite and porphyry, mixing together strata and eruptive rocks, an attempt which was unexpected from a stratigraphical geologist. His Huronian system is formed of a mixture of the St. Albans group of the Upper Taconic, with the Triassic rocks of Lake Superior, the trap native-copper bearing rocks of Point Keeweenaw, and the dioritic dyke containing the copper pyrites of Bruce mine on Lake Huron.

The different dislocations which have affected the rocks of the vicinity of Quebec have not brought to light the complete series of the Taconic nor of the Lower Silurian, and the difference of opinion that exists between Mr. Logan and myself is partly owing to this want. In his *Remarks on the Fauna of the Quebec Group of Rocks and the Primordial Zone of Canada*, Jan., 1861, and in his *Considerations relating to the Quebec Group*, May, 1861, Mr. Logan gives the following series for the vicinity of Quebec: —

u^2. — Dark gray shales and sandstones (Hudson River).
u^1. — Black shales (Utica).
b. — Limestone (Birdseye, Black River, and Trenton).

q^6. — Sandstone and red shales (Sillery).
q^5. — Red and green shales.
q^4. — Green and gray shales and sandstones.
q^3. — Sandstones and magnesian conglomerates.
q^2. — Green shales.
q^1. — Magnesian conglomerates and shales.
} Quebec Group.

p^2. — Sandstones.
p^1. — Black shales and limestones.
} Potsdam.

g. — Gneiss (Laurentian).

All the fossils found at Point Levi are placed by Mr. Logan in a single group of strata, which he calls the *Quebec group*. He speaks also several times of shales and limestones beneath the Quebec group, which he considers as deep-water deposits of the Potsdam Sandstone. Unhappily he does not give any precise localities or section at Quebec or Point Levi where that Potsdam may be found, and I was unable to discover what strata he thus names. But wherever these strata may be located, he says that he found no fossils in them in Canada, "but that the shales resemble those in which *Oleni* have been found in Georgia." So that Mr. Logan considers the *Georgia Slates* and the *Potsdam Sandstone* as the *same* group, one being a deep-water deposit and the other a coast deposit. I will only remark that at Mr. Parker's house, in Georgia, the two groups are found one above the other.

Mr. James Hall, in his last descriptions of the Georgia Trilobites (*Thirteenth Annual Report of the State Cabinet of Natural History*

of New York, 1861), overlooking the remarks of Mr. Logan on the Georgia Slates, includes the *Georgia Slates* in the *Quebec group*, adding new confusion to an already very diffuse explanation.

In a tabular view of my observations in the vicinity of Quebec, we shall have the following theoretical section: —

THEORETICAL SECTION OF THE ROCKS OF THE VICINITY OF QUEBEC.

	GROUPS.	FEET.	LOCALITIES, SUBDIVISIONS, FOSSILS.	
LOWER SILURIAN.	LORRAINE SHALES.		Not seen.	Second fauna.
	UTICA SLATE.	40	Montmorency Falls.	
	TRENTON LIMESTONE.	30	Montmorency Falls, Beaufort, and Indian Lorette.	
	BLACK RIVER GROUP.		Not seen.	
	CALCIFEROUS SANDSTONE.	600	*a.* Blue schistose marls, interstratified with conglomerates and blue limestone. Compound *Graptolites*. Citadel, City of Quebec, and Point Levi. *b.* Gray slates, sometimes blackish, with alternation of yellow sandstone, magnesian conglomerate, and 20 or 30 feet of gray limestone. The limestone is very fossiliferous: *Bathyurus Saffordi*, *B. Cordai*, *Ecculiomphalus Canadensis*, *Camerella calcifera*, etc. Terre du Curé at Point Levi. The lower part of the group is not visible.	
TACONIC.	POTSDAM SANDSTONE.		Not seen.	Primordial fauna.
	LINGULA FLAGS.		Not seen.	
	GEORGIA SLATES.		Not seen.	
	ST. ALBANS GROUP.	3000	*a.* Green, brown, and black slates of Gilmor wharf, east of Point Levi, and also on the road to Arlaka. Containing the large lenticular mass of whitish gray limestone of La Redoute or Guay quarries. The Redoute limestone contains: *Dikellocephalus*, *Conocephalites*, *Menocephalus*, *Arionellus*, *Orthisina*, *Capulus* and *Crinoids*. *b.* Sillery and Chaudière red slates and sandstones.	

Quartzites of Montmorency Falls. Its position in the Lower Taconic still undetermined.

Lorraine Shales or Hudson River Group. — Mr. Logan, in his section from Montmorency to the Island of Orleans, regards the bed of the St. Lawrence as entirely formed by dark gray shales and sandstones, which he considers of the age of the Hudson River group. Having no diving apparatus at my disposition, I was unable to follow him to the bottom of the St. Lawrence. If this group really exists in the vicinity of Quebec, it will be brought out by a careful examination of all the strata between Ste. Foix and Indian Lorette.

Utica Slates. — Dr. Emmons, in his *Geology of New York*, 1842, p. 117, refers the slates of Montmorency Falls to the Utica Slates, having found there the characteristic Trilobites of *Triarthus Beckii.* Dr. Bigsby also calls them Utica slates (*On the Geology of Quebec and its environs*, 1853), and so did, after their example, Mr. Logan. In my short exploration of 1849, I erroneously considered those black slates of Montmorency Falls as older than the Trenton Limestone forming the summit of the falls; but at my recent visit I found the opinion of the geologist above named to be correct.

Trenton Limestone. — The thirty feet of limestone at the top of Montmorency Falls, and at the foot of the precipice immediately in contact with the quartzite, are of the Trenton Limestone age, as Mr. Logan has stated in his description of Montmorency formations; fossils are very abundant in both places.

Black River Group. — I was unable to refer any strata to the subdivisions of this group. Mr. Logan does not give any special localities for it, having only put it in his diagram and theoretical section without other notice.

Calciferous Sandstone. — This group is composed, at the summit, of blue schistose marls, interstratified with thin bedded limestones, blue and sometimes almost black, and large masses of conglomerate, the size of the rounded pebble attaining even that of the true boulder. In this upper part, especially in the cliff on the road from the ferry to Notre Dame church at Point Levi, are found a quantity of the celebrated compound *Graptolidæ.* The citadel and the old town of Quebec are built on it. Then there is a succession of gray slates, sometimes almost black, with alternations of yellowish coarse sandstone, magnesian conglomerate, and twenty or thirty feet of a gray limestone, brecciated, hard, and very fossiliferous. I did not see the lower part of the Calciferous Sandstone; perhaps it has been concealed by the dislocations, or was never deposited in this part of Canada. The thickness of the whole is about six hundred feet. This number appears at first a small one, but if we take into consideration the numerous foldings of this deposit, and also the narrow band it forms, it will be seen to be sufficient, for the ridge which it forms is never more than a mile and a half in width, extending from Quebec to the Plains of Abra-

ham, Claremont, and Cape Rouge, the extremity of Point Levi, and a little of the cliff west of it, and finally a part of the island of Orleans. It rests unconformably upon the different subdivisions of the St. Albans group; that is to say, on the Taconic slates of Gilmor Wharf, the Redoute limestone, and the Sillery and Chaudière red rocks. This unconformability is somewhat difficult to make out, because the strata have been so dislocated, folded, and squeezed, that they often appear as if they lay below the St. Albans group instead of being above, as they are in fact. But patient and numerous observations made with a theodolite, or a good compass, will clear up all the difficulty.

In *Remarks on the Fauna of the Quebec Group*, &c., Mr. Logan gives some details, calling separate exposures or outcrops, A, A^1, A^2, A^3, A^4, B^1, B^2, and B^3, and considering the whole as one group of strata. I tried without success to understand his explanation when I was at Point Levi, his memoir in one hand and my hammer in the other. The only thing I was able to make out was: 1st, that what he calls the more northern outcrop, A^2, was mainly the quarries of the Notary Guay, or the *Redoute limestone;* I say mainly, for other strata may be included in it, of limestone and conglomerate which surround the lenticular mass of the Redoute*; 2d, that his outcrops A^1, A^3, A^4, B^1, B^2, and B^3, were a single group of strata, with repetition of several beds by folding, situated between the churches of St. Joseph and Notre Dame, a little east of that line, and in a parcel of ground called by the Canadians *Terre du Curé* (land of the Curate of St. Joseph); 3d, the cliff A is exposed very well on the road leading from the ferry to Notre Dame church.

Mr. Logan includes also in his Quebec group the Sillery red shales and sandstones, the whole having, perhaps, a thickness of five or seven thousand feet, and regards it as the equivalent of the Calciferous Sandstone and Chazy Limestone. The Chazy Limestone is a small subdivision of the Black River group, and I did not see it, or any equivalent of it. The cliff A is in part subdivision *a* of the Calciferous Sandstone of my tabular view. The outcrops A^1, A^3, A^4, B^1, B^2, and B^3, form entirely my subdivision *b;* I will call them *strata de la terre du Curé.* The fossils are very numerous in several beds, especially in some of the brecciated limestone; the most common are: *Bathyurus Saffordi, B. Cordai, B. bituberculatus, B. quadratus; Cheirurus Apollo, C. Eryx; Agnostus; Ecculiomphalus Canadensis, E. intortus; Holopea dilucula; Pleurotomaria; Murchisonia; Orthoceras; Cyrtoceras; Orthis; Camerella calcifera*, etc., all belonging to the second fauna. Mr. Logan

* So called by the older Canadians because there was a Redoubt there during the last French war.

names several fossils, especially Trilobites, *Bathyurus* and *Menocephalus*, which are common to the outcrops A^1, A^3, A^4, B^1, B^2, and B^3 (*strata de la terre du Curé*) and the outcrop A^2, but I did not find any; it may be that some boulders and pebbles of A^2, or *la Redoute* Limestone, are enclosed in the conglomerates of the different beds of the *strata de la terre du Curé*.

The outcrop A^2 is entirely distinct from the others. It is true that La Redoute is almost entirely surrounded by small bands of Calciferous Sandstone, that form as it were the frame of a small island, but such accidents are not rare in much disturbed and dislocated countries, and it is not difficult to see that La Redoute is independent of all the other hills of Point Levi, forming a conspicuous landmark, which can be seen from all the environs of Quebec, and having a north and south or meridian direction, in common with the whole of the Green Mountain system, which put an end to the Taconic deposits, while the other hills of Point Levi and Quebec run north-east and south-west. The *strata de la terre du Curé* do not include, I think, all the Calciferous Sandstone, as it is developed in Vermont and Phillipsburgh; the lower part, or white limestone of Phillipsburgh shore, is wanting here.

Potsdam Sandstone. — I did not see any rocks in the vicinity of Quebec which I can refer to this capping group of the Taconic system.

Lingula-flags. — Not seen.

Georgia Slates. — Not seen.

St. Albans Group. — This lower group of the upper Taconic is well developed on the south shore of the St. Lawrence, which it occupies almost entirely, with the exception of one or two miles at Point Levi. It extends far into the interior. Its thickness is at least three thousand feet. The upper part is composed of green, brown, and black slates, affected by numerous lines of cleavage, and can be seen very well developed near the Gilmor Wharf, east of Point Levi, also on the road from St. Joseph's church to Arlaka, at one mile from the church. I consider the Redoute Limestone, or quarries of the Notary Guay, as forming a lenticular mass inclosed in them, similar to one that I observed at St. Albans. I did not find any fossils in the slates, except the *Chrondites*, so common and characteristic of all the upper Taconic slates. The Redoute Limestone presents a highly interesting fauna. The strata are almost perpendicular, with a direction almost due north, and a deviation to the east of 5° or 7°. The stratification is indistinct, as it always is with lenticular masses. The limestone is gray, almost white, very hard, sometimes oölitic, with little veins of chalcedony. Its whole thickness cannot be less than eighty or one hundred feet. In some of the strata fossil remains are numerous, but composed only of

fragments, chiefly heads and *pygidia* of Trilobites; and it is very difficult to obtain specimens on account of the great hardness of the stone. I succeeded, however, in collecting the following species: *Conocephalites Zenkeri; Dikellocephalus magnificus, D. planifrons, D. megalops, D. cristatus; pygidia* of a *Dikellocephalus* not named by Billings, but figured No. 11 and 12; *Arionellus cylindricus, A. subclavatus; Menocephalus Sedgewicki, Menocephalus globosus;* a large *Capulus*, an *Orthisina*, and the stems and even the foot of a Crinoid.

All the known species of the Redoute limestone have been described in a masterly manner by Mr. Billings in his memoir, *On some species of Fossils from the limestone near Point Levi, opposite Quebec*, August, 1860. I did not find the *Dikellocephalus Belli* and *D. Oweni*, nor *Agnostus Americanus, A. Orion* and *A. Canadensis*, which Mr. Billings describes as part of his fauna of Limestone No. 1. Without touching the stratigraphical question, Mr. Billings separates the species under the heads of Limestones Nos. 1, 2, 3, and 4. His numbers 2, 3, and 4, are evidently what I call the Calciferous Sandstone strata, and his No. 1 represents in part the *Redoute Limestone*. I say in part, for, perhaps, he has put in No. 1 some specimens resembling those of the *Redoute Limestone*, especially when broken in very small fragments, that really belong to the *strata de la terre du Curé*. For instance, I found a good specimen of his *Bathyurus bituberculatus*, not at the Redoute, but at the *terre du Curé*, and I did not find a single specimen or trace of the genus *Bathyurus* in the Redoute Limestone; consequently my observations in the field do not lead me to consider the genus *Bathyurus* as a primordial one; it belongs exclusively to the lower part of the second fauna. According to my observations, the fauna of the Redoute Limestone is entirely primordial, without any mixture whatever of fossils of the second fauna, being limited to the genera *Conocephalites, Dikellocephalus, Arionellus, Menocephalus, Capulus, Orthisina*, and a Crinoid, which characterize the primordial fauna in America as well as in Europe.

The inferior part of the St. Albans group is formed by what has been called the Sillery and Chaudière red shales and sandstones, in which no fossils have as yet been found. In Canada this part of the group is much more developed than in Vermont, or perhaps the difference in colors is due to metamorphism in Vermont.

Finally, there is a beautiful *quartzite* at the falls of Montmorency, which Mr. Logan, for an unknown reason, continues to call Laurentian *gneiss*. It forms the bed of the Montmorency river and the chasm of the precipice. It is indistinctly stratified by beds from ten to twelve feet thick, very ~~dark~~ hard and compact, and has all the characters of a metamorphic sandstone or true quartzite. Direction or strike N. 45° E. to S. 45° W., dipping south-east at an angle of 80 or 85 degrees.

Such is the series of rocks seen by me in the vicinity of Quebec. Mr. Logan says, "from the physical structure alone no person would suspect the break that must exist in the neighborhood of Quebec; and without the evidence of the fossils every one would be authorized to deny it;" thus throwing on Paleontology all the mistakes made and all the difficulties accumulated in his Quebec Group. I ask permission to say that the Stratigraphical and Lithological differences between the Silurian and Taconic rocks of the vicinity of Quebec are to me at least as great and as plain as the Paleontological ones; and that I find no facts whatever which show any conflict between Paleontology and Stratigraphy.

It is doubtful if all the shales between the chasm of Montmorency Falls and the waters of the St. Lawrence are of the Utica Slate age; the *Graptolitas bicornis* and *G. pristis* are found in the *black shales* near their contact with the Trenton Limestone, but as yet no fossils have been found in the *gray shales*. In the ravine east of the Falls, there is probably a fault between the black and gray Shales; the dipping of the Trenton Limestone, the black Shales and gray Shales, disagrees, and varies from fifteen to eighty degrees, in a space of less than 150 feet. I am inclined to consider the gray Shales as the upper part of the Calciferous Sandstone group, but it will require further investigations in the field to determine the true stratigraphical structure of Montmorency Falls.